The Goal of Quiet(er) Flight for Sustainable Aviation

National Colloquium on Sustainable Aviation

Mark Huising

Senior Engineering Specialist

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Aircraft Noise: First Aviation Sustainability Issue?

Noise became an issue soon after the start of civil jet transportation

- Noise from operation of the Boeing 707 forced authorities at London Heathrow and New York Idlewild (now JFK) airports to impose noise limits and install monitoring systems

Numerous lawsuits in the US and outcry in major European cities led to an international conference in London in 1966 that endorsed the concept of noise certification of aircraft

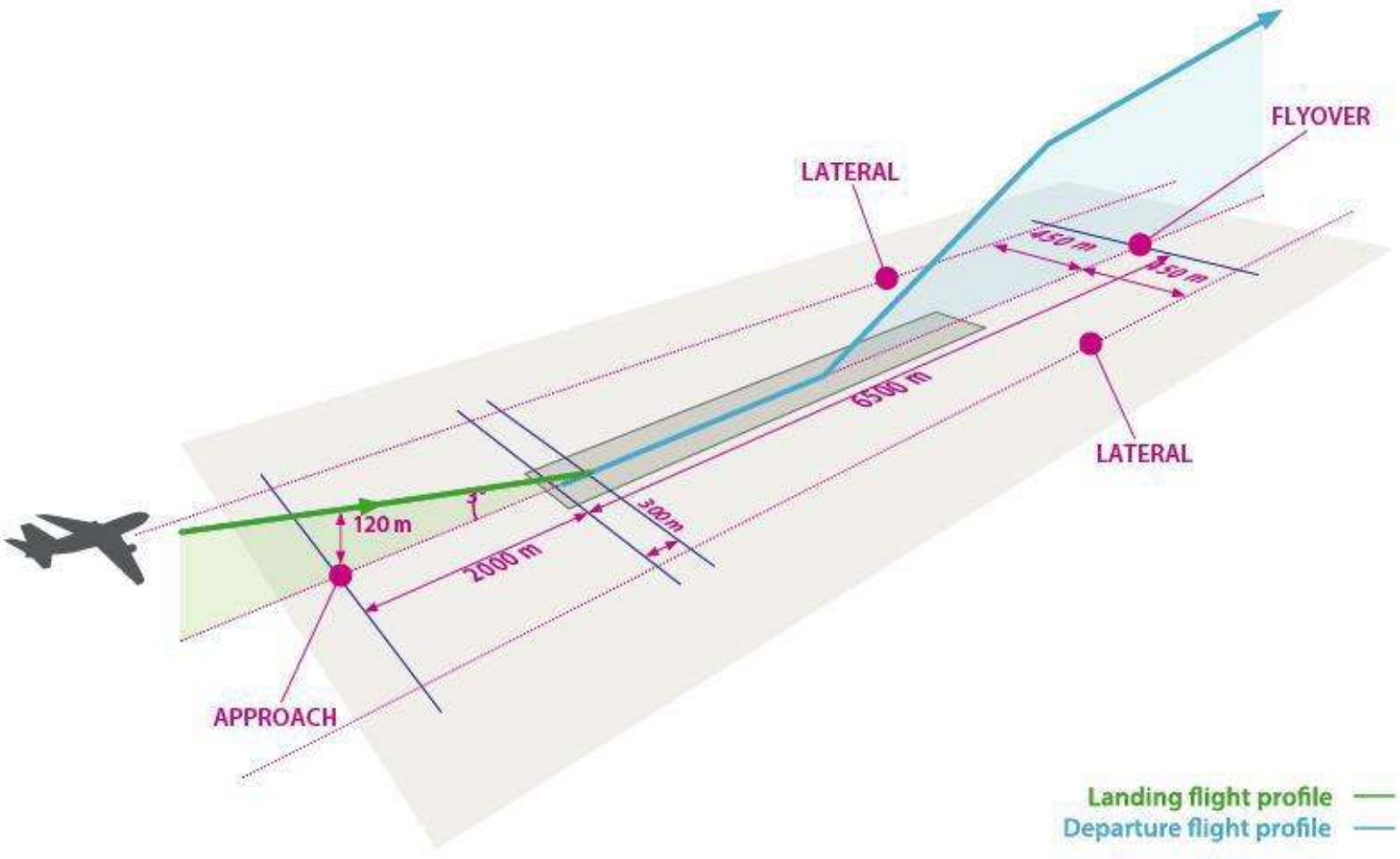
A letter from the FAA to US manufacturers in that same year is telling:

- *"it could well be that the most significant deterrent to continued growth is related to problems associated with aircraft noise"*
- *"The accelerated growth of air transportation combined with the development of larger and more powerful aircraft, the enlargement of many airport facilities, and the engulfing of lands immediately surrounding our airports by urban communities all contribute to a growth of the noise problem on a national scale."*

In 1969, a Notice of Proposed Rule Making for a noise certification scheme was introduced in the US and a special meeting was held at the ICAO to develop international standards

from Smith (1989)

Jet and large propeller airplane noise certification



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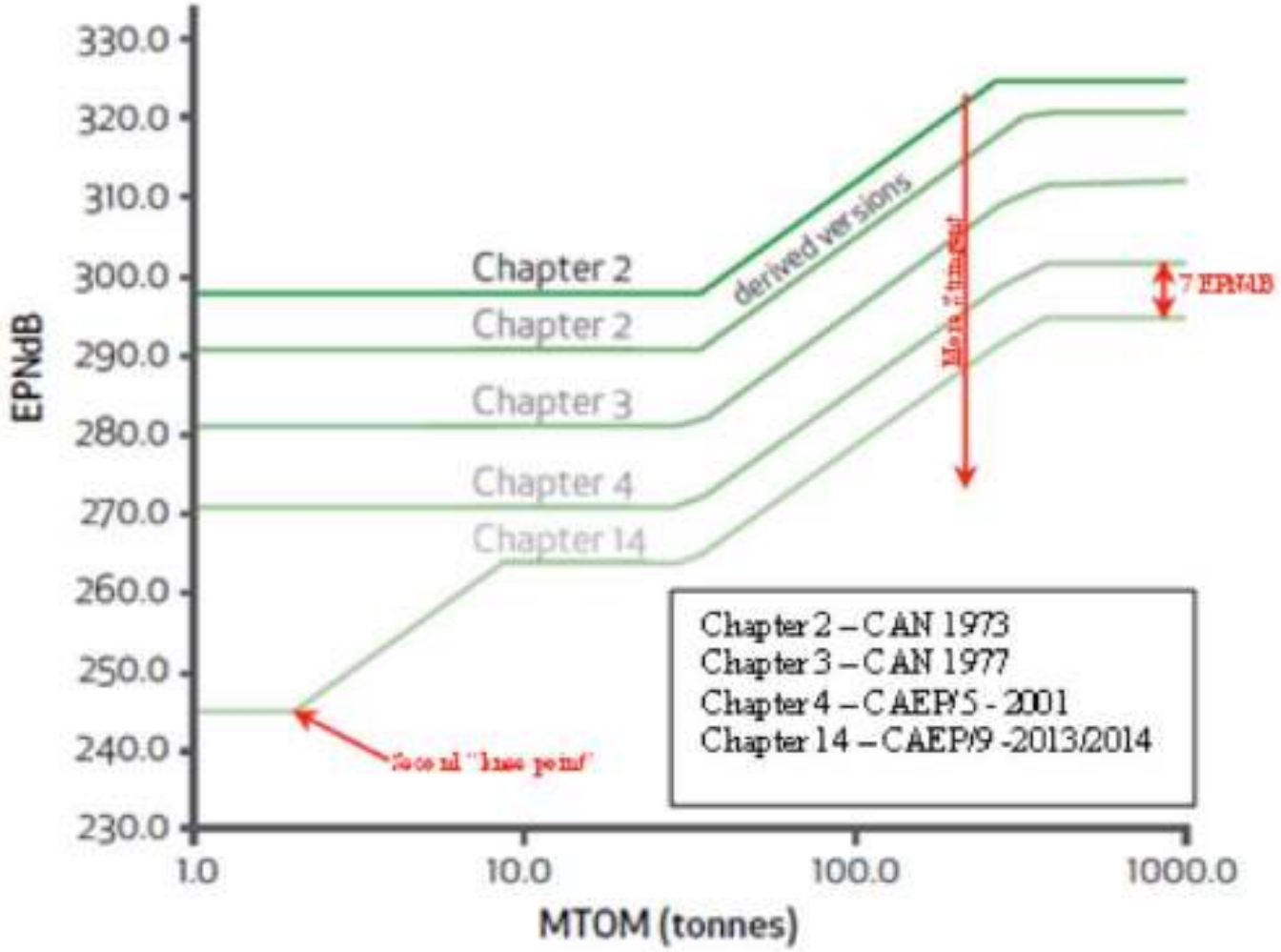
Where are we now with noise certification levels?



from ICAO Environment Report (2016)

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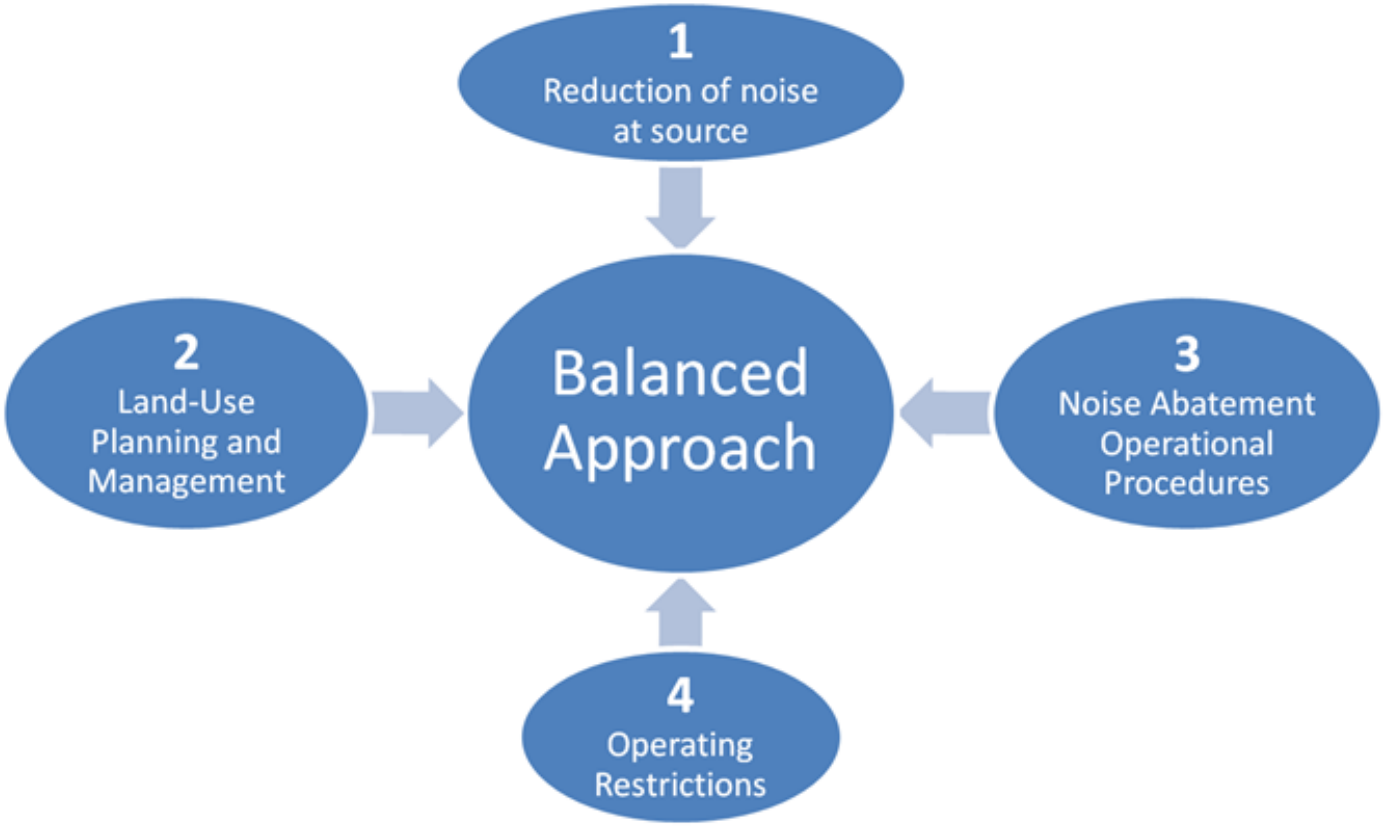
The ICAO “Balanced Approach to Aircraft Noise Management”

The Balanced Approach was formally adopted by the ICAO in 2004



from www.icao.int/environmental-protection/Pages/noise.aspx

Increasing air traffic drives environmental goals

DLR/SES experiment to detect Automatic Dependent Surveillance Broadcast (ADS-B) aircraft signals using the Prova-V microsatellite (https://phys.org/news/2015-05-proba-v-world-air-traffic-space.html)

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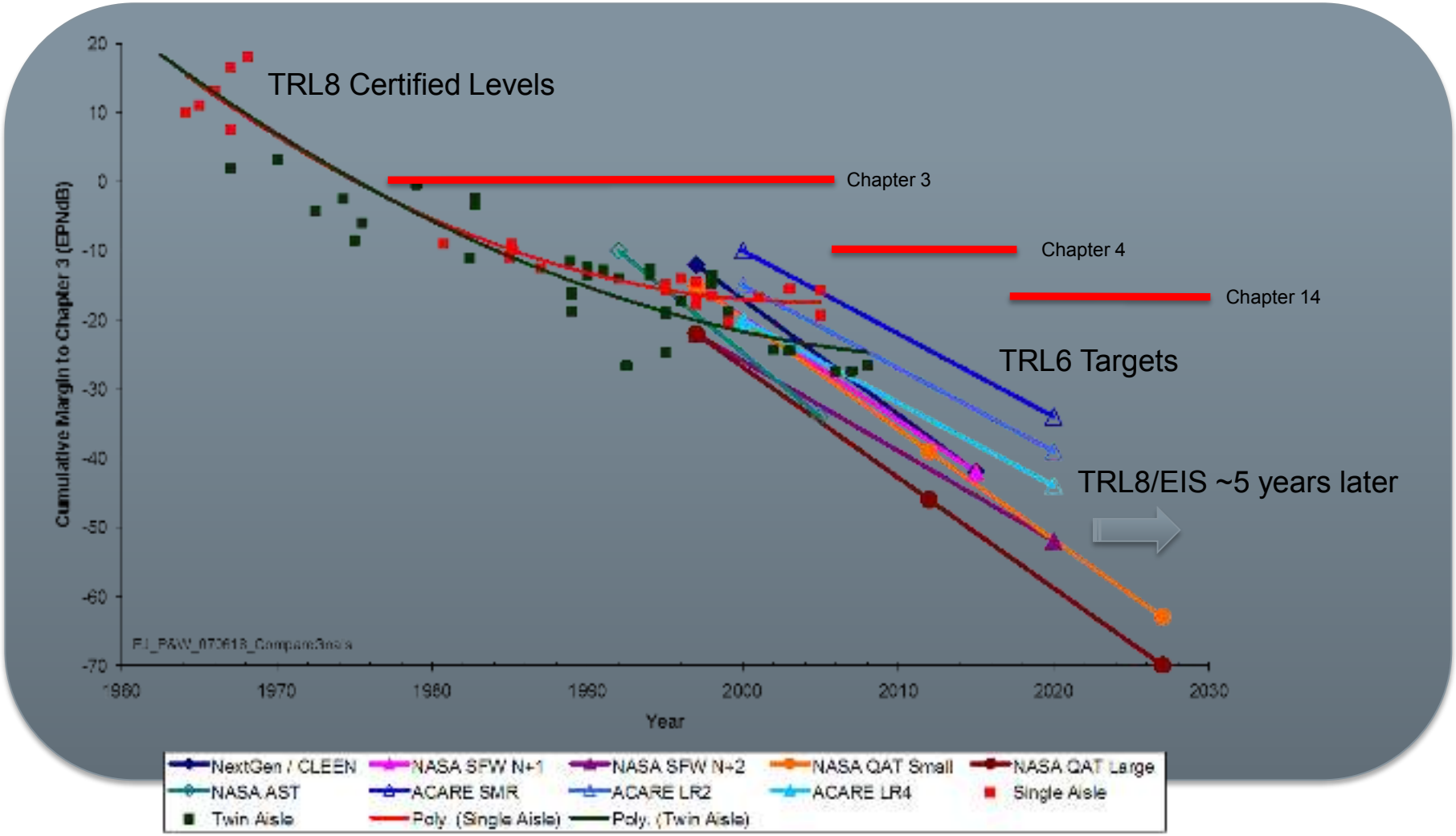
International noise goals drive noise research programs



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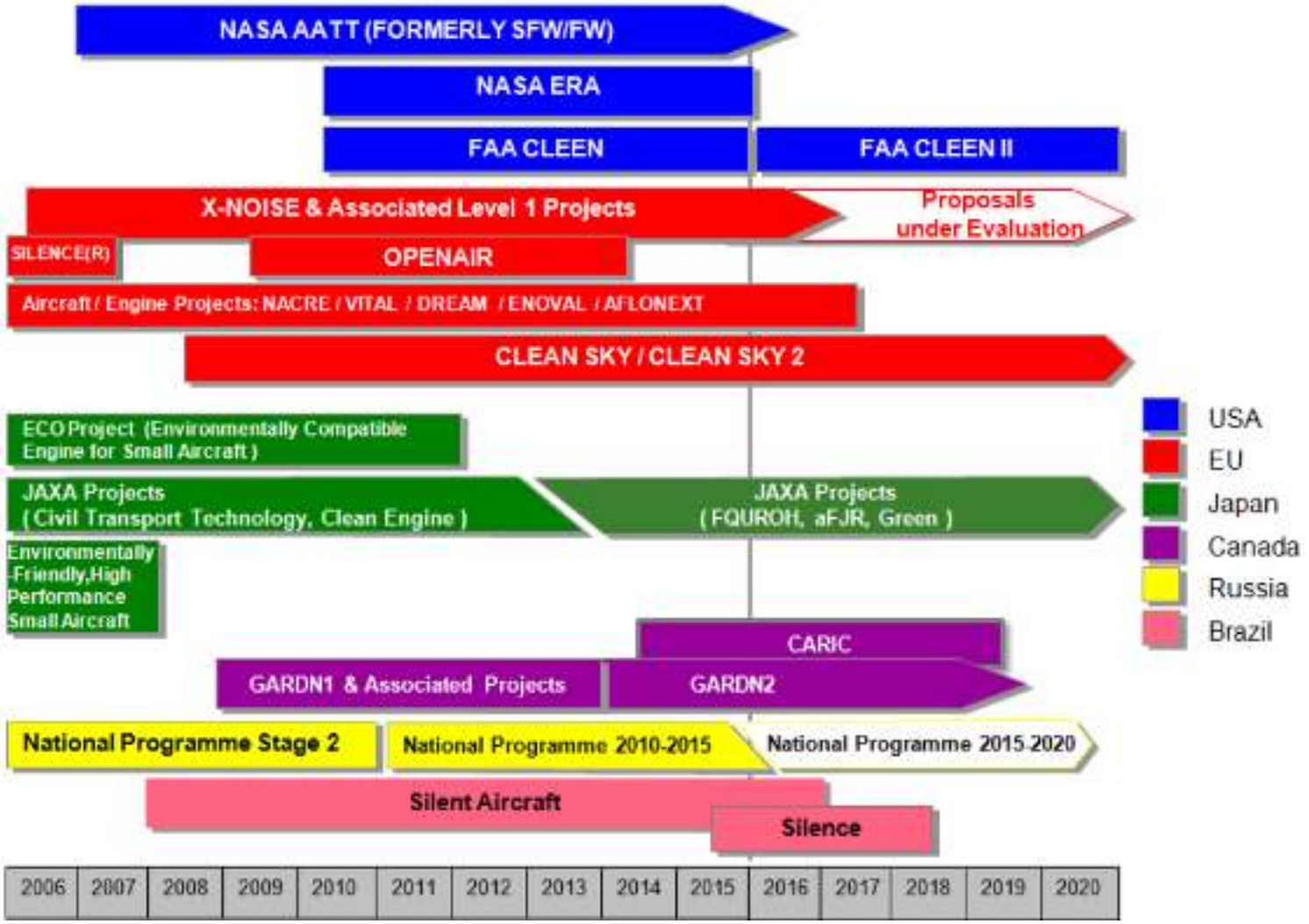
International noise technology programs



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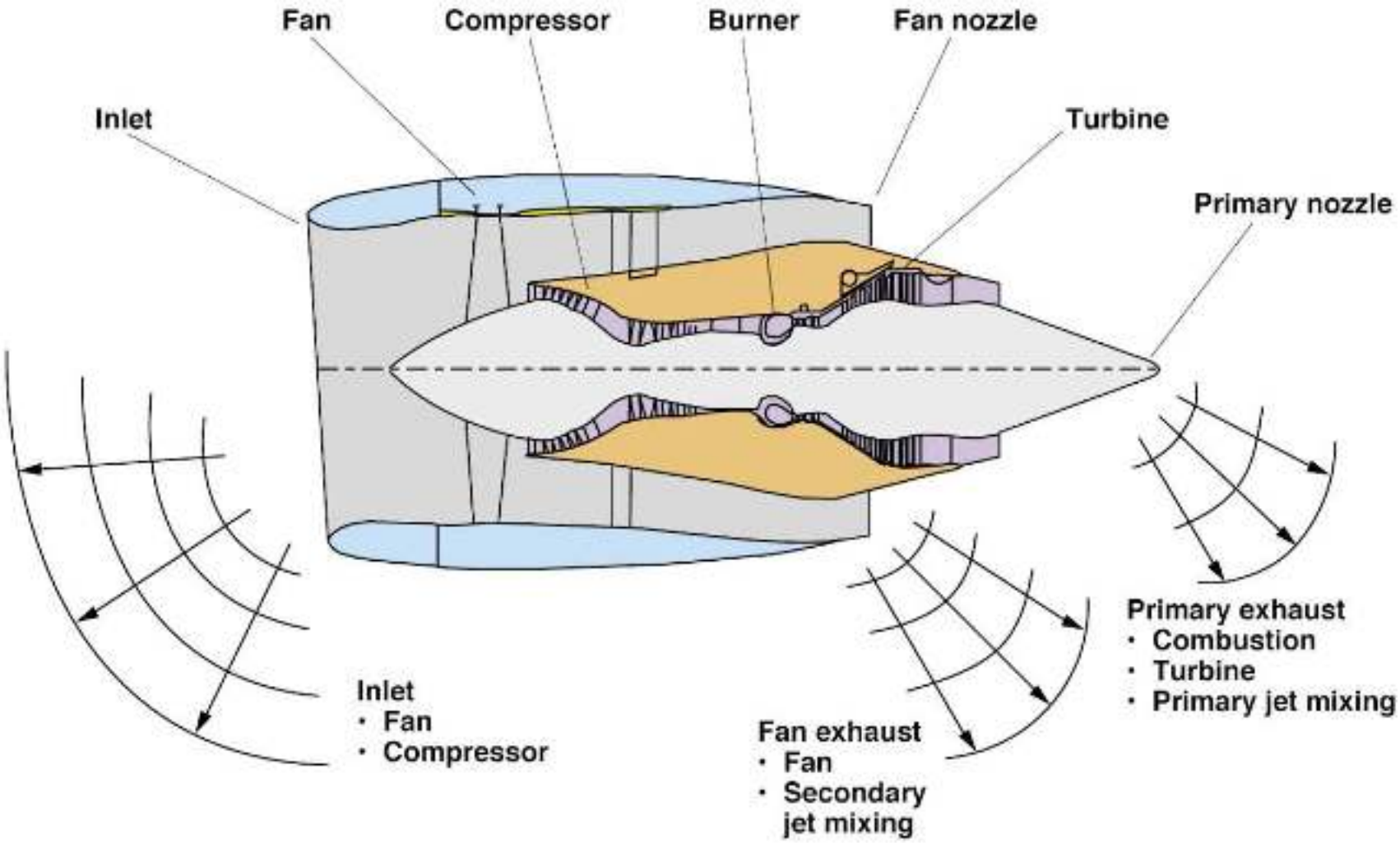
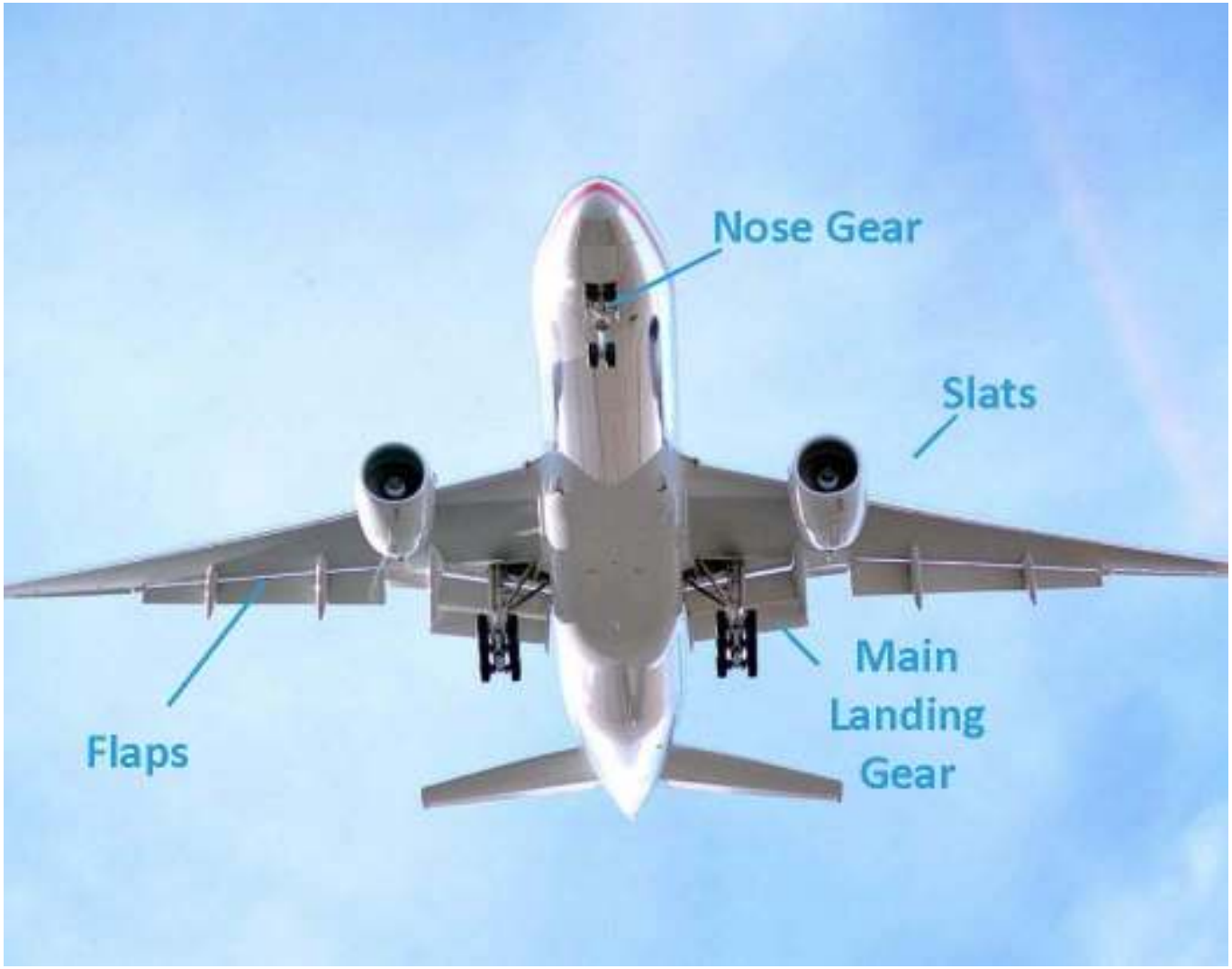
Engine noise sources



Airframe noise sources



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Mid-term noise goals of the US and EU

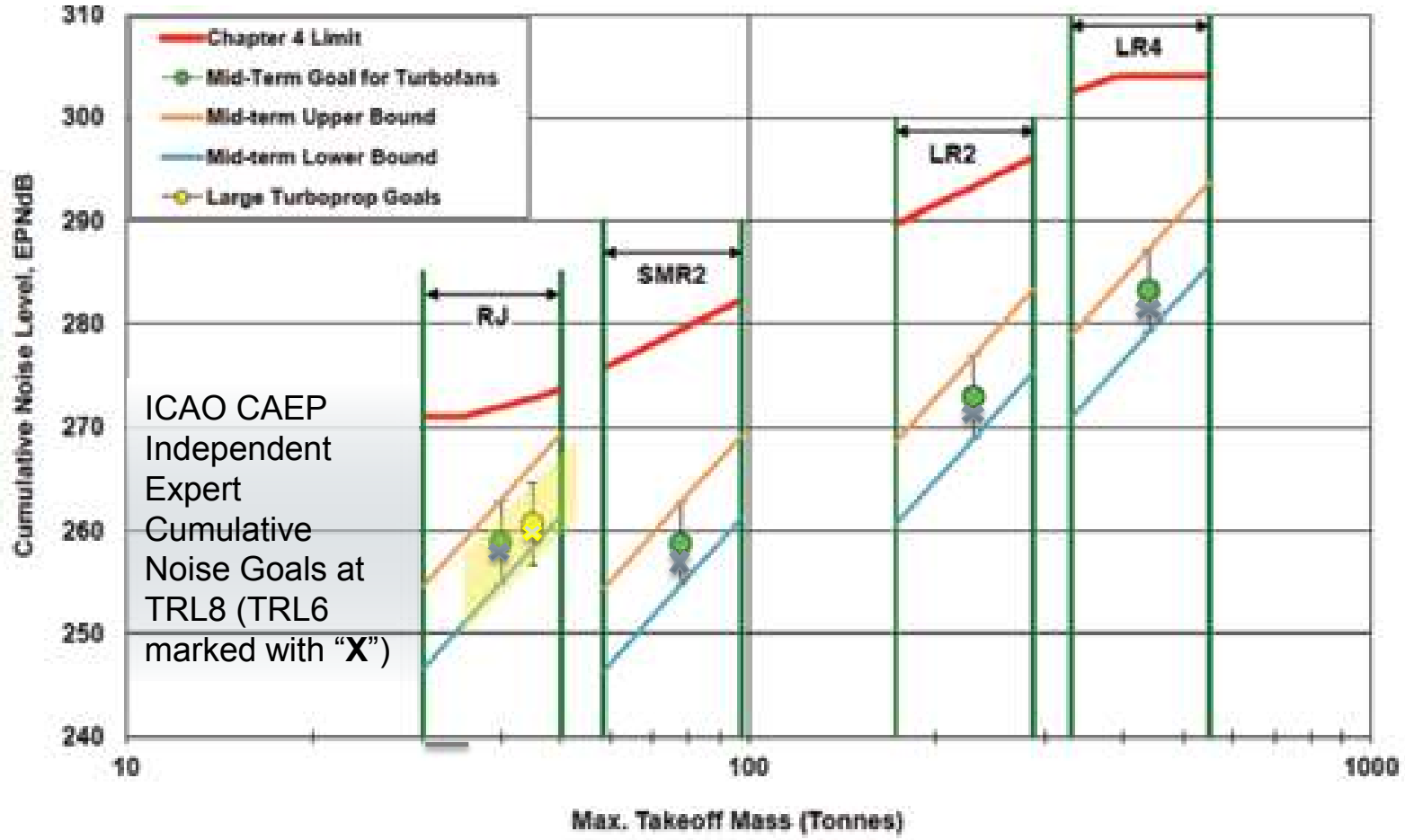
United States

- FAA Destination 2025
  - community noise concerns not a significant constraint on growth
- NextGen:
  - Reduce the number of people exposed to significant noise around U.S. airports in absolute terms, notwithstanding aviation growth, and provide additional measures to protect public health and welfare as well as national resources.
  - One of the 5 NextGen pillars is to mature new aircraft technologies
    - CLEEN goal: 32 dB cumulative margin to Chapter 4 (TRL6-7 by 2020 with EIS in 2025)

Europe

- ACARE Vision 2020
  - Eliminate noise nuisance outside the airport boundary by day and night by quieter aircraft, better land planning and use around airports and systematic use of noise reduction procedures
  - 50% reduction in perceived noise relative to year 2000 technology (10 dB reduction per movement)

Mid-term international noise technology goals (2020)



from ICAO Environment Report (2013)

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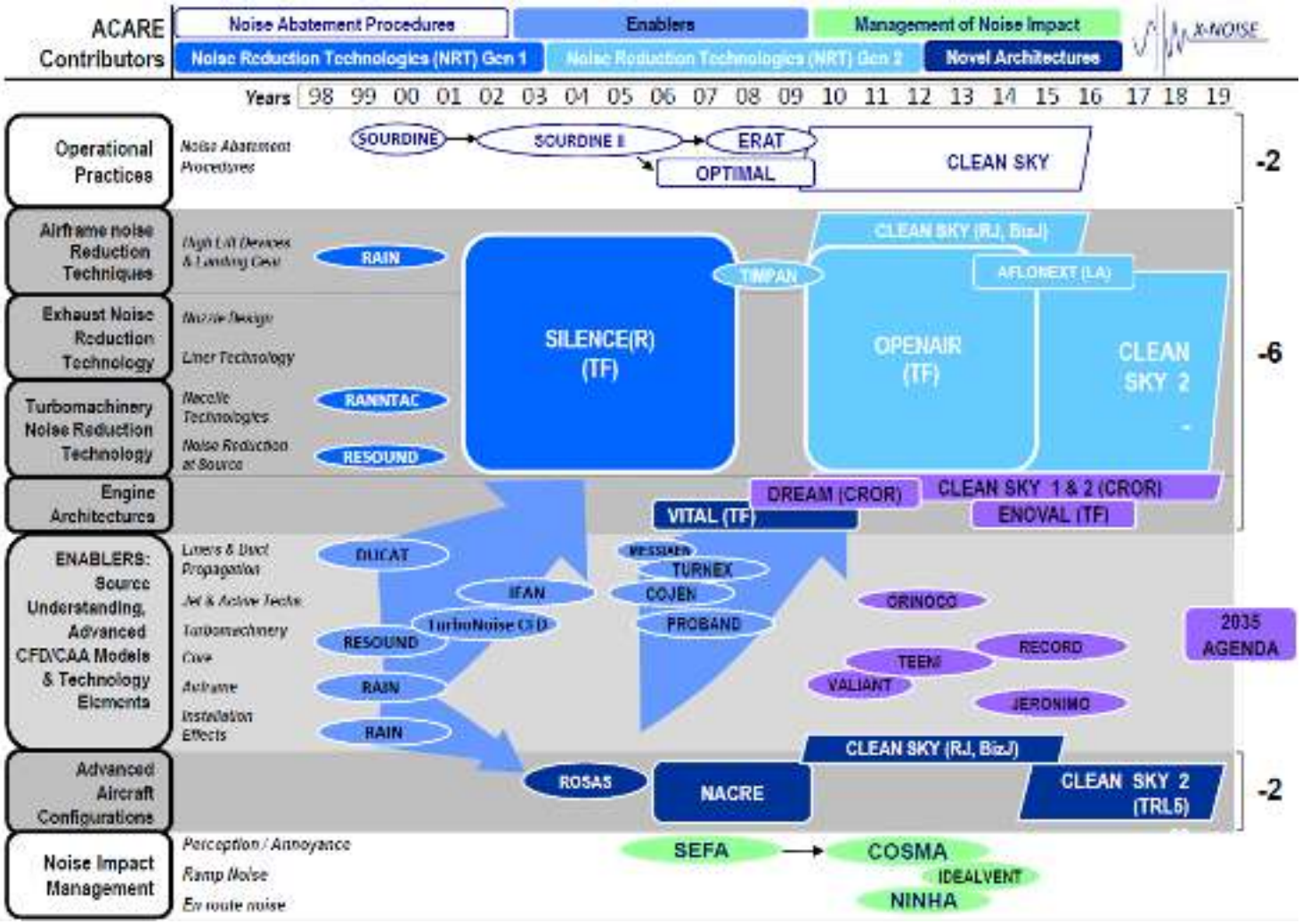
X-Noise Roadmap / “Swimlanes” for ACARE Vision 2020



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Long-term noise goals of the US and EU

United States (NASA):

TECHNOLOGY BENEFITS*	TECHNOLOGY GENERATIONS (Technology Readiness Level = 4-6) v2013.1		
	N+1 (2015)	N+2 (2020**)	N+3 (2025)
Noise (cum margin rel. to Stage 4)	-32 dB	-42 dB	-52 dB
LTO NO_X Emissions (rel. to CAEP 6)	-60%	-75%	-80%
Cruise NO_X Emissions (rel. to 2005 best in class)	-55%	-70%	-80%
Aircraft Fuel/Energy Consumption† (rel. to 2005 best in class)	-33%	-50%	-60%

* Projected benefits once technologies are matured and implemented by industry. Benefits vary by vehicle size and mission. N+1 and N+3 values are referenced to a 737-800 with CFM56-7B engines. N+2 values are referenced to a 777-200 with GE90 engines.

** LRA's time phased approach includes advancing "long pole" technologies to TRL 6 by 2015

† CO_2 emission benefits dependent on life cycle CO_2 per MJ for fuel and/or energy source used

Europe

- ACARE Flightpath 2050
  - 65% reduction in perceived noise relative to year 2000 technology (~15 dB reduction per movement)

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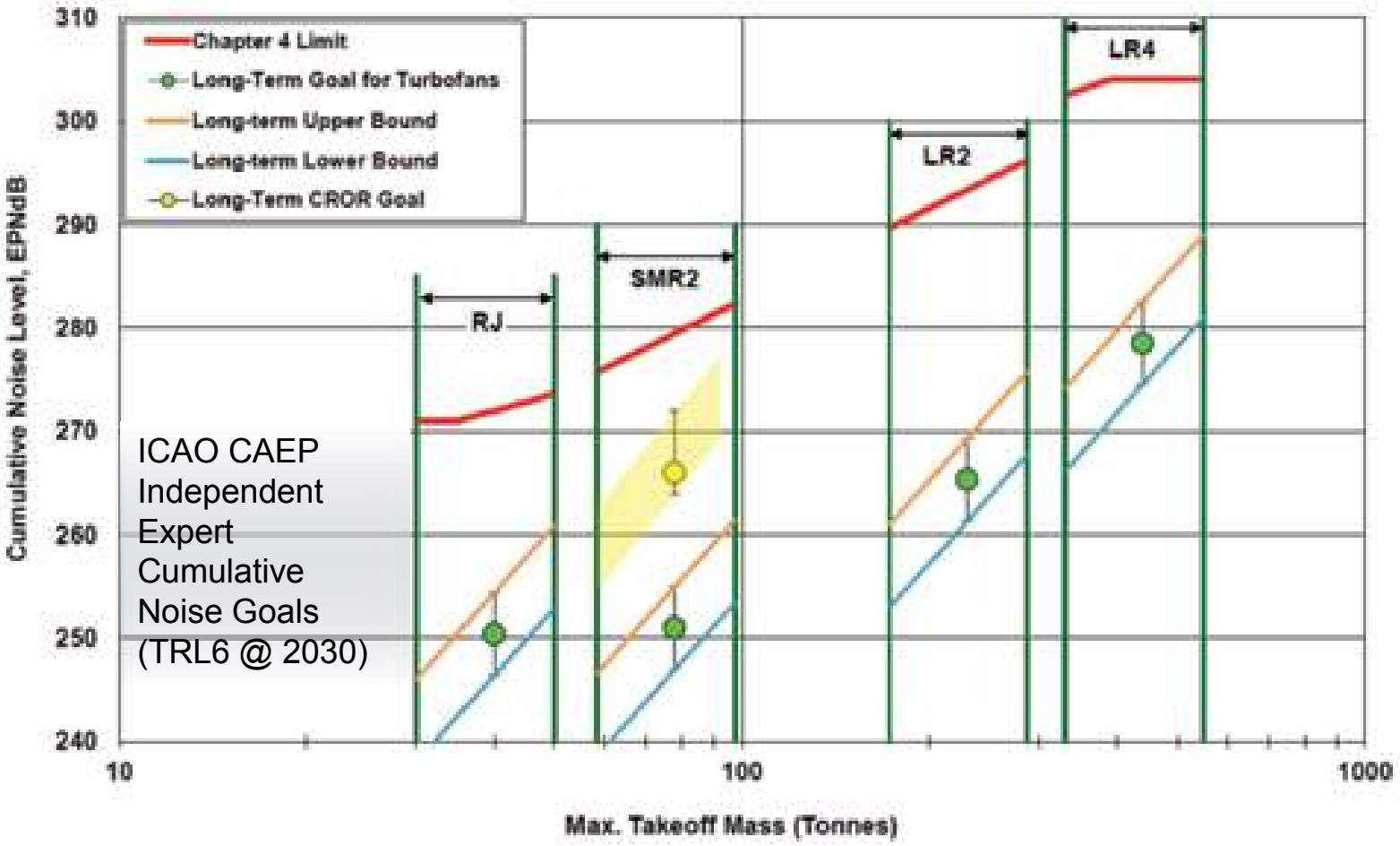
Long-term international noise technology goals



from ICAO Environment Report (2013)

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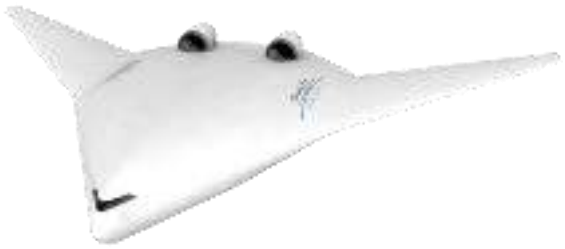
Long-term advanced configurations for “step change”



New concepts tend to shield engine noise to achieve much of the benefit.

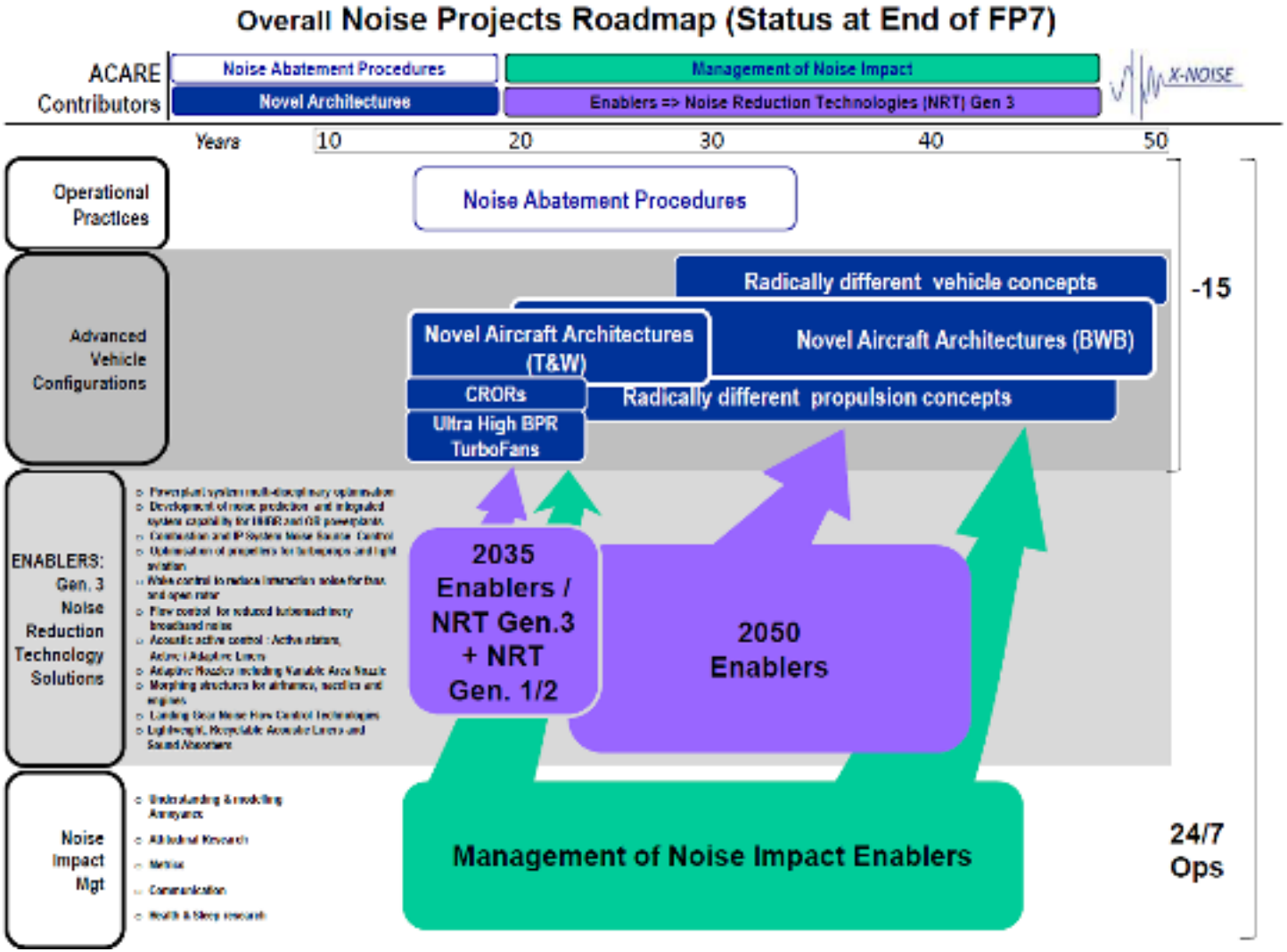
NASA ERA and X-Planes programs

NASA Environmentally Responsible Aviation (ERA) project recently completed. Noise reduction progress described in AIAA-2016-0863.

- Hybrid wing-body designs showed greatest impact
- 11.9 EPNdB cumulative improvement from engine shielding for 300 passenger size

Development of scale-model flying demonstrators has begun through the X-Planes program.

X-Noise Roadmap for ACARE Flightpath 2050



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Green Aviation Research and Development Network (GARDN)

Noise Source Reduction Projects

GARDN2: funding period 2014 through 2019

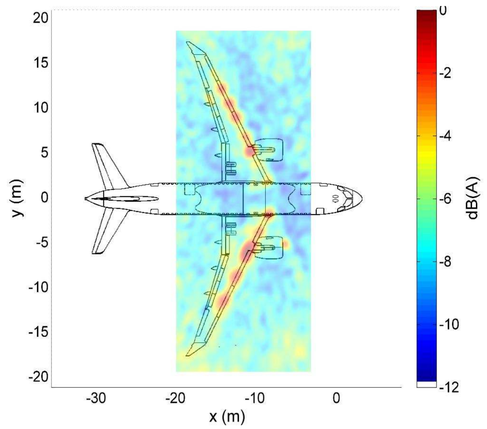
- Airframe Noise Reduction for Business and Commercial Aircraft (BA-22)
- Noise Reduction for Next Generation Regional Turboprop (PWC-22)
- Noise measurements of Innovative Environmentally Friendly Aircraft Configuration (BA-23)

BA-22

AIRFRAME NOISE REDUCTION FOR BUSINESS AND COMMERCIAL AIRCRAFT

Project Goal: To evaluate and improve new A/C designs for exterior noise through improved modeling and development of noise reduction techniques.

PHASE ARRAY TECHNOLOGY



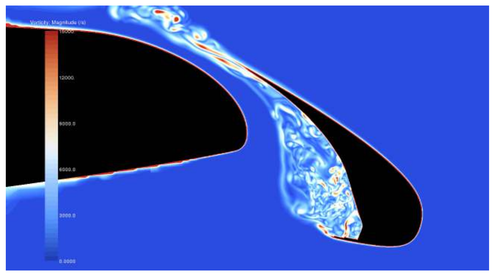
Advanced algorithms for enhance sound source localization, particularly low frequency methods, have been developed.

This tool can identify any noise generating components on new aircraft for potential improvement prior to certification testing.

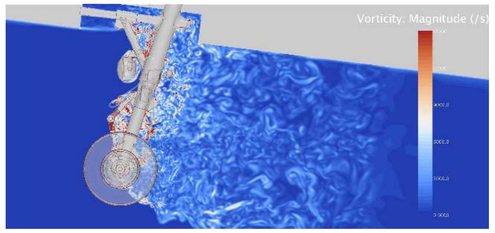
HIGH-LIFT NOISE PREDICTION AND REDUCTION

Numerical study of high-lift devices enables Bombardier to identify noise sources and design slats and flaps for lower noise levels.

Improved computational methods help determine the strength and location of noise sources and provides insight to address potential issues.



LANDING GEAR PREDICTION AND REDUCTION



Nose and main landing gears are main contributors of airframe noise.

Because of their blunt three-dimensional geometry, massive separation occurs around the geometry. This makes study of the landing gears specially challenging.

Numerical results are being validated by high-quality on-surface and far-field experimental measurements.

SEMI-EMPIRICAL METHODS

Phased array technology plus CAA results have been used to enhance traditional semi-empirical methods for prediction of airframe noise.

Semi-empirical methods are critical for inclusion of noise optimization early in the aircraft design process.

PARTNERS

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HÉROUX DEVTEK

Institute for Aerospace Studies
UNIVERSITY OF TORONTO
Centre for Research in Sustainable Aviation

Canada
NRC·CNRC

BA-23

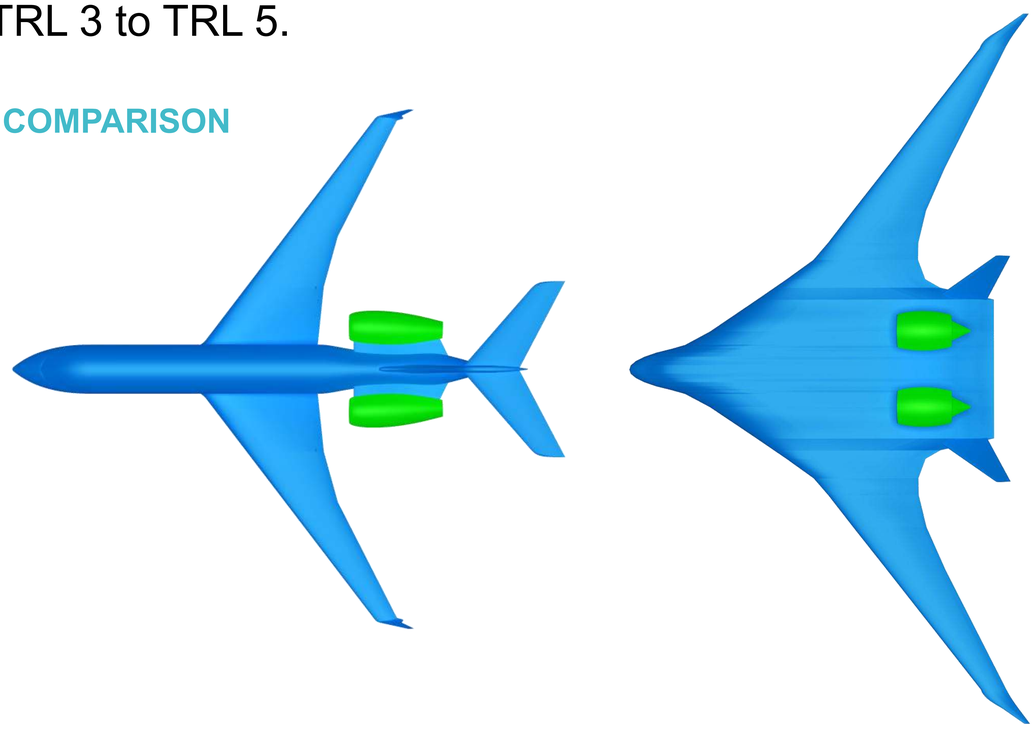
NOISE MEASUREMENTS OF INNOVATIVE, ENVIRONMENTALLY FRIENDLY AIRCRAFT CONFIGURATION

Bombardier, the National Research Council (NRC) and Université de Sherbrooke (UdS) will conduct acoustic emission field measurements to determine aircraft noise using NRC's anechoic acoustic chamber facility and a point source developed by UdS. The project partners will first measure sound on a conventional aircraft for validation and tool calibration, and then conduct measurements on a novel aircraft configuration. A wind tunnel model created as part of the ongoing GARDN program (BA-21) will be re-used for the acoustic measurements. The technology readiness level (TRL) will progress from TRL 3 to TRL 5.

CONVENTIONAL AND NOVEL AIRCRAFT IN COMPARISON

It is apparent that the novel configuration (center image) may have an advantage over the conventional configuration (left image) by using the wing, body and tail to shield the engine noise from propagating to the ground. The difference will be quantified in an anechoic chamber (right image).

Note: novel aircraft modeled by Bombardier using data found in: Bonet, J. T., "Boeing ERA N+2 Advanced Vehicle Concept Results", 50th AIAA Aerospace Sciences Meeting, 2012-01-11.



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